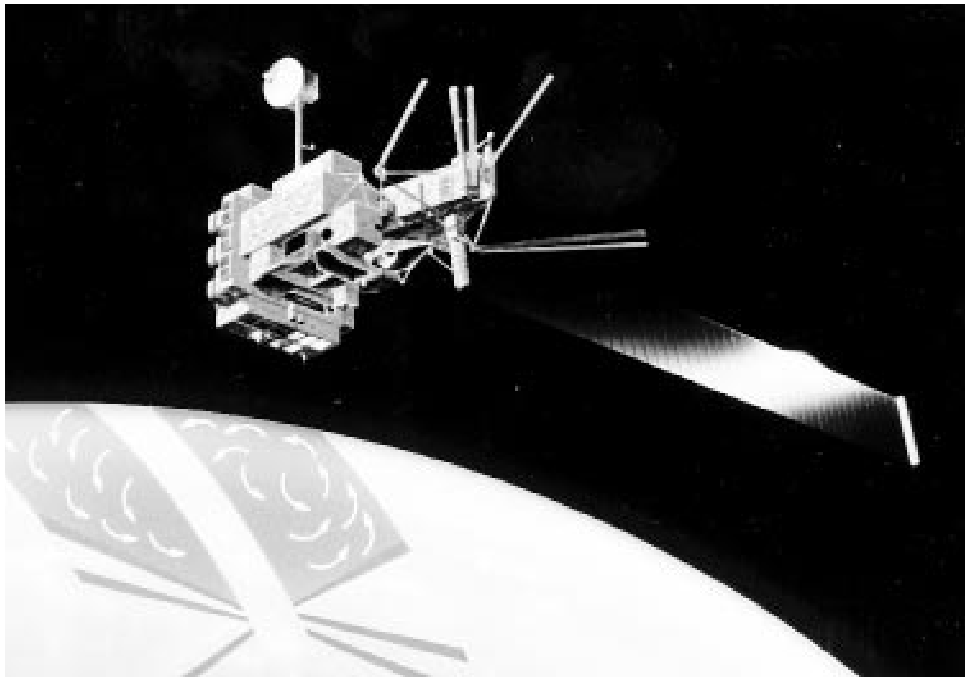
NASA Scatterometer (NSCAT)



Winds that blow across the ocean surface play a pivotal role in global weather and climate changes as they couple together oceanic and atmospheric circulations.

As part of NASA's efforts to apply advanced space technology to understand the Earth and its climate, scientists and engineers at the Jet Propulsion Laboratory have designed a satellite instrument that will measure near-surface ocean winds.

Called the NASA Scatterometer (NSCAT), the instrument will be launched in August 1996 onboard the Advanced Earth Observing Satellite (ADEOS) by Japan's National Space Development Agency (NASDA) for at least a three-year mission.

Information from NSCAT will help scientists predict climate changes and improve weather forecasts, and will also help them understand ocean circulation and the role of air-sea interactions in the global ecosystem.

NSCAT will take 190,000 wind measurements per day, mapping more than 90 percent of the world's ice-free oceans every two days. The instrument will provide more than 100 times the amount of ocean wind information currently available from ship reports — and, because NSCAT is a radar instrument, it is capable of taking data day and night, regardless of sunlight or weather conditions.

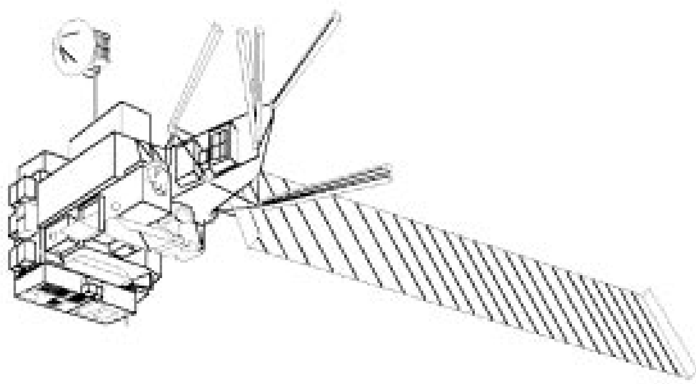
NSCAT will complement other current and future NASA satellites and oceanographic missions of the international scientific community. In addition to advancing the scientific understanding of the ocean and the atmosphere, NSCAT will provide tangible benefits to a variety of maritime businesses. Shipping, fishing, offshore oil drilling and even recreational sailing will all benefit from more accurate weather forecasting and the reporting of regional winds. Residents of coastal areas would also be alerted when strong winds are approaching.

Why Study Ocean Winds?

Winds are a driving force for oceanic motions, ranging from small-scale waves to large-scale systems of ocean currents. Winds directly affect the turbulent exchanges of heat, moisture and greenhouse gases between the atmosphere and the ocean. These air-sea exchanges, in turn, determine regional weather patterns and shape global climate.

Current knowledge of ocean surface winds come mostly from localized, infrequent and often inaccurate reports from ships. NSCAT's space-based vantage point offers coverage that is both frequent and global, under all weather conditions. Such features are critical to understanding and predicting complex worldwide weather and climate changes.

Weather Forecasting: One of the main applications for NSCAT data will be in weather forecasting. Nearly two-thirds of our planet is covered by oceans, where there are no weather stations and only a scat-



tered array of buoys. This lack of information hampers our knowledge of today's weather and, thus, impedes our ability to forecast the future. Most of the weather over the United States' west coast is generated over the ocean. NSCAT's frequent, extensive and all-weather coverage will alleviate this problem and provide substantial information for predicting the weather. The National Oceanic and Atmospheric Administration (NOAA) will process the data in near-real time and distribute it to NOAA's National Weather Service, Japan's Meteorological Agency and other users who will incorporate the NSCAT measurements into their forecast models. These data are important in short-term weather warnings and forecasts and will play a key role in our ability to understand and predict complex global weather patterns and climate systems.

Storm Detection: NSCAT measurements can determine the location, structure and strength of storms at sea. Severe marine storms — hurricanes in the Atlantic, typhoons near Asia and midlatitude cyclones worldwide — are among the most destructive of all natural phenomena. In the United States alone, hurricanes have been responsible for at least 17,000 deaths since 1900, and have caused hundreds of millions of dollars in damage annually. If worldwide statistics are considered, the numbers are substantially higher. And while midlatitude cyclones are not usually as violent as hurricanes and typhoons, these storms also exact a heavy toll in casualties and material damage.

In recent years, our ability to detect and track severe storms has been dramatically enhanced by the advent of weather satellites. Cloud images from space are now routine on TV weather reports. NSCAT data will augment these familiar images by providing a direct measurement of the surface winds to compare to the observed cloud patterns. These wind measurements can help to more accurately identify the extent of gale force winds associated with a storm, and will provide inputs to computer models that provide advanced warnings of high waves and flooding.

El Nino and Other Research Studies: An El Nino event occurs when there is a change in the normal weather conditions in the equatorial Pacific Ocean. During an El Nino year, a large region of unusually warm water moves across the equator toward South America when the easterly winds weaken in the western portion of the Pacific. This warm water alters weather and rainfall patterns, wind directions and even the jet stream. The affects of these changed patterns are felt all over the world. NSCAT wind measurements in this region of the Pacific will help scientists more accurately predict when El Nino will occur.

Another important application of the NSCAT technology will be in the study of world climate. Most of the heat absorbed by the Earth is stored in the tropics near the equator. Through the process of ocean circulation — and the winds that drive the ocean — the world's climate is predominately regulated as heat from the tropics is transported to higher latitudes. Precise knowledge of the winds over the global ocean will enable scientists to better understand this complicated process.

Monsoon: A monsoon is the seasonal change of winds which is caused by the difference in temperatures over land and water. Monsoons affect a large areas of the world, but are perhaps most common in the Indian Ocean and Southeast Asia. Its annual onset, intensity, and retreat vary greatly, and the variation of a monsoon has strong economic impact and may cause severe human suffering. Beside bringing rain to land, a monsoon also changes ocean currents, upwelling, and associated biological activities. Over land the consequences of monsoon are well observed, but the monsoon's breeding ground over the ocean has been insufficiently monitored. The scatterometer, with its repeated global observations and unprecedented spatial resolution, will help scientists monitor and understand the monsoon.

Ship Routing: Wind observations from NSCAT could be of particular significance in shipping. In addition to identifying storms that might harm vessels and crews, captains of ocean-going cargo ships will be able to chart their courses more efficiently. Prior knowledge of winds will enable ships to choose routes that avoid heavy seas or high headwinds that could slow the ships' progress and increase fuel consumption.

Oil Production and Clean Up: Oil and gas production takes place at numerous offshore sites around the world — the Gulf of Mexico, the North Sea, the Persian Gulf, and other areas. Thorough knowledge of the historical wind and wave conditions at any specific location is crucial to the design of drilling platforms. Safe efficient drilling operations depend on an accurate understanding of the current sea state and warnings of impending storms.

In the event of an oil spill, surface-wind information is key to determining how the oil will spread. NSCAT could help clean-up and containment crews to minimize the environmental effects of such a disaster.

Food Production: Perhaps the oldest use of the ocean is the harvesting of food. Today, ocean fishing is a highly systematic activity that makes extensive use of advanced technology to reduce the cost and to increase value of every "catch." Detailed wind data from NSCAT can aid in the management of commercial seafood crops. For example, the annual U.S. shrimp harvest in the Gulf of Mexico depends on favorable on-shore wind that transport plankton larvae to estuaries where the larvae can develop into adult shrimp.

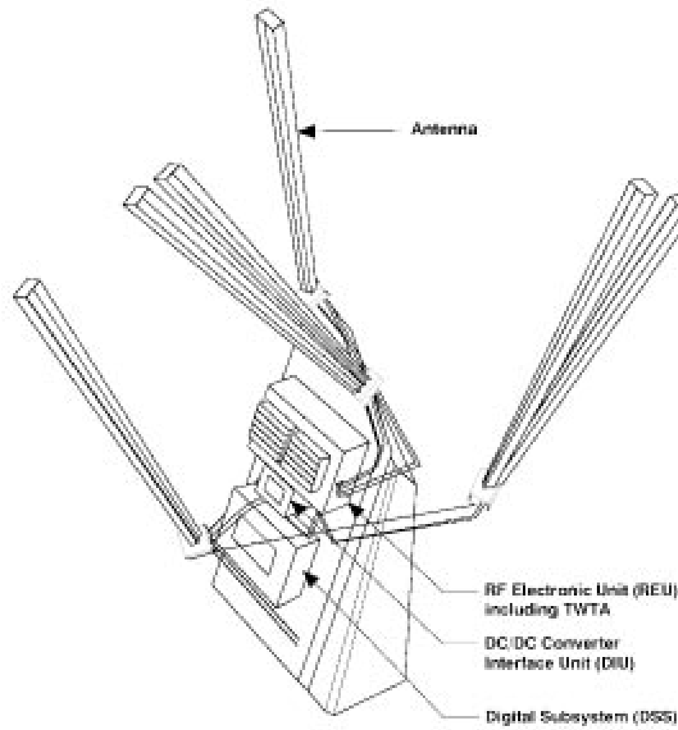
The Scatterometer Concept

The principle behind NSCAT's operation has been developed in the decades since World War II.

In the 1950s and 1960s, radar operators on naval and merchant ships experienced a troublesome phenomenon called "sea clutter." Appearing on radar screens as noise which obscured small boats or low-flying aircraft, this clutter was in fact radar pulses returned from the ocean surface.

This reflection — or "backscattering" — of the radar pulses is caused by the interaction of the radar signal with 1- to 3-centimeter (half- to 1-1/2-inch) rippling waves, also called "cat's paws," on the ocean's surface.

While electronics were developed to reduce this phenomenon in conventional radar where it is not wel-



come, researchers realized that radar instruments could be optimized to specifically make use of this backscattering.

Scientists discovered a link between such ocean waves and the speed of wind just above the ocean's surface. By sending radar pulses from an airborne or spaceborne instrument and then measuring the "backscattered" signal, they could indirectly gauge ocean wind speed.

Scatterometers can do more than just measure wind speed. The backscattered signal is also shaped by the direction of the wind in relation to how the radar is pointed. By measuring backscattering with two or more radar antennas pointed at different angles, the scatterometer can also reveal wind direction.

After early tests on aircraft and on NASA's Skylab mission in the 1970s, a scatterometer was launched on JPL's experimental ocean monitoring satellite Seasat in 1978. NSCAT is broadly based on the concepts of the Seasat scatterometer with improvements in many areas.

The NSCAT Instrument

Like its predecessor on Seasat, NSCAT uses an array of stick-like antennas that radiate microwave pulses at a frequency of 14 GHz (14 billion cycles per second) across broad regions of the Earth's surface. A small fraction of the radar pulses are reflected back and are captured by NSCAT's antennas.

After the signals are amplified and processed, they are sent to receiving stations on Earth. Ground-based computers use the transmitted data to calculate wind speed and direction.

At any given time, NSCAT's array of six dual-beam antennas — each measuring 3 meters by 20 centimeters by 20 centimeters (10 feet by 6 inches by 6 inches) — scans two bands of ocean on either side of the satellite's near-polar sun-synchronous 800 kilometer (500 mile) orbit. Each band is 600 kilometers (375 miles) wide. The bands are separated by a gap of about 350 kilometers (215 miles) directly below the satellite where no data collection is possible.

In addition to the antenna array, NSCAT is composed of a radar transmitter-receiver and a computer for onboard processing and control of the instrument. Total weight of NSCAT is about 286 kilograms (about 660 pounds), and it uses about 240 watts of power.

Wind measurements will be accurate to within 2 meters per second (4.5 miles per hour) in speed and 20 degrees in direction. Each wind measurement will have a spatial resolution of 50 kilometers (30 miles), although higher resolution 25-kilometer (15-mile) measurements are possible.

NSCAT and its host satellite, ADEOS, are scheduled to be launched on an H-II rocket from Tanegashima Space Center, some 1,000 kilometers (625 miles) southwest of Tokyo, on August 16, 1996.

Ground Processing and Analysis

In addition to providing the scatterometer instrument, JPL is developing a specialized ground system that will process NSCAT data for the scientific community. The project office has also provided NOAA with software to process the NSCAT data that NOAA will then distribute to meteorological agencies around the world. After the NSCAT Project has processed the data, the data will be archived and distributed by the NASA-sponsored Physical Oceanography, Distributed Active Archive Center (PODAAC) located at JPL. NASA'S Earth Observing System Data and Information System (EOSDIS) is sponsoring the PODAAC.

Data from NSCAT will be available to the general public through the National Oceanic and Atmospheric Administration. NOAA plans to provide both real-time data to the public and to use the data in its forecast models which may enable more accurate long range weather predictions. JPL will take the real-time data and present it on its NSCAT World Wide Web home page:

http://www.jpl.nasa.gov/winds

Science and Management Teams

The NSCAT Project has a team of 15 scientific investigators who have advised the project during the instrument's development and who will conduct research with NSCAT data once it is in orbit.

The NASA science team collaborates with a similar team composed of Japanese oceanographers and meteorologists sponsored by Japan's NASDA.

The JPL project scientist is Dr. Timothy Liu. The NASA program scientist for ADEOS is Dr. Ramesh Kakar.

The NSCAT Project is sponsored by NASA's Office of Mission of Planet Earth, Washington, D.C. At JPL, the project manager is James Graf. The NASA program manager for ADEOS is Ken Ford.

❑

8-96 MAH